[0032] As a feature, the multi-touch sensitive display surface according to the invention does not require any physical buttons as found on a mouse, or other user interface.

[0033] Displayed graphic objects are controlled arbitrarily by touching the surface at or near locations where the objects are displayed. By controlling, we mean that the objects can be moved, dragged, selected, highlighted, rotated, resized, re-oriented, etc, as they would by a mechanical mouse. Re-orientation is defined as a translation and a rotation of the item with a single touching motion. The touching can be performed by fingers, hands, pointing or marking devices, such as a stylus or light pen, or other transducers appropriate for the display surface.

[0034] In order for mouse emulation to be smooth and natural on such a multi-touch sensitive display surface, a number of things are desired.

[0035] First, it is required to precisely position the cursor, a type of graphic object, on the display surface. This is a particular problem when fine positioning is attempted with a finger because the physical location of the finger typically obscures the virtual position of the cursor on the display surface.

[0036] Second, there must be a simple mechanism to switch between positioning mode, i.e., just moving the cursor, and engagement mode, i.e., dragging, or drawing.

[0037] Third, it is undesirable for this switching mechanism to require movement of the cursor itself. For example, after the cursor is moved to the display position that coincides with the physical location of the finger on the multi-touch sensitive surface, the cursor should remain at the same location during the switching.

[0038] Fourth, and perhaps most important, any solution for emulating mouse control should "feel" very easy and natural.

[0039] According to one embodiment of the invention, when a user touches the touch-sensitive surface with one finger, the system behaves as though a left mouse button is pressed. This facilitates a simple and intuitive behavior when the user is performing common operations such as scrolling, dragging, and drawing.

[0040] However, this makes it awkward to perform 'mouse-over' operations such as positioning the cursor to activate menu items, and tool tips, and image rollovers in web pages, wherein moving the cursor over images changes the appearance of the images. If the left mouse button is held down during what would normally be a mouse-over operation, then the text may become unexpectedly selected, for example.

[0041] As shown in FIG. **2**A, when two fingers **201**-**202** touch the surface **200** concurrently, e.g., the middle finger and the thumb, the cursor **210** is displayed at a mid-point location between the positions of the two fingers as a graphic object, as shown in FIG. **2**B. This provides a view of the cursor that is not obscured by the fingers. Repositioning the fingers relocates the cursor accordingly. If the distance between the two fingers is increased or decreased, then the cursor will continue to be displayed at the mid-point location, as shown in FIG. **2**C.

[0042] As shown in FIG. **3**, after the cursor **210** has been located, the user can tap the surface **200** with a third finger **301**, e.g., the index finger, to simulate a left mouse press, i.e., holding the left mouse button down. This allows the user to smoothly switch between positioning and engagement modes, while positioning the cursor **210**. It does not matter where the third finger taps. However, the active tapping area can be restricted to a rectangular bounding box **310** having opposing diagonal corners defined be the position of the two fingers **201**-**202**. This technique enables the user to keep two fingers in contact with the surface while smoothly and accurately positioning the cursor, in a mouse-like manner.

[0043] FIG. **4** shows how the user can draw a line **401**, which is another graphic object, by relocating the hand as indicated by the arrow **410**. At the beginning of the movement, the user taps the surface with the third finger **301** to enable drawing mode, instead of just positioning the cursor. The completion of the 'move' is indicated by lifting the third finger, or by lifting all three fingers at about the same time.

[0044] In practice, it seems most natural to use the thumb and middle finger of one hand to enter the cursor positioning mode. This allows the index finger to be used for tapping in between the other two fingers.

[0045] However, if the hand obscures the cursor or other displayed content, then the user can use two index fingers **501**-**502** to locate the cursor as shown in FIG. **5**. As an advantage, increasing the distance between the two fingers can increase the accuracy of the cursor positioning.

[0046] It seems to be most natural and stable for a human hand to use the thumb and middle finger of one hand to specify the cursor position. The two fingers tend to 'anchor' the touch, which is particularly important when trying to precisely position of the cursor.

[0047] FIGS. **6**-**10** are state diagrams that emulate mouse-like events using a multi-touch display surface according to embodiments of the invention. The 'rounded boxes' indicate states, the rectangular boxes indicate the mouse-like events, and the directed arcs indicate self explanatory transitions between the various states.

[0048] To emulate clicking the left mouse button, the user simply taps quickly at a desired location. To emulate double-clicking with the left mouse button, the user simply taps twice quickly at the desired location.

[0049] FIG. **6** shows the states that emulate mouse left clicking and dragging. The states are no fingers down **601**, one finger down **602**, and dragging with one finger **603**. The events are left click **611**, left button down **612**, left button up **613**, and dragging with the left button **614**. When the finger is repositioned or 'dragged', while the finger remains in contact with the surface, the cursor is displayed at a location corresponding to the position finger, and the cursor engages with the displayed graphical object. The type of engagement depends of the underlying application. For example, when the graphical object is text in word processor, the engaging highlights the text, as would be the case if a mouse were used. If the object is the title bar of a 'window', the window is dragged along with the finger.

[0050] According to an embodiment, to emulate pressing down the right mouse button, the user presses one finger down on the surface at the desired location, and then